**Summary Report for NSAC Meeting, January 29-30, 2001**

# Nuclear Science Division
# Lawrence Berkeley National Laboratory

**Nuclear Science Division**

| DOE Ops Funding | FY2000 | | FY2001 | | |
|---|---|---|---|---|---|
| | $15.80 M | | $16.10 M | | |
| NSD Staff* | Perm. Ph.D. | Tech/Admin | Postdocs | Grad Students | Undergrads |
| FY2000 | 42 | 13/10 | 18 + 12 term Ph.D.s | 14 | 7 |

* Staffing does not include 21 non-supported people (e.g., visiting fellows, associated faculty, retirees...) who are a significant resource

**88-Inch Cyclotron National Facility**

| DOE Ops Funding** | FY2000 | | FY2001 | |
|---|---|---|---|---|
| | $4.14M | | $4.28M | |
| Staff** | Perm. Ph.D. | Tech | | |
| FY2000 | 3 | 7 NSD + 13 Engineering/Maintenance | | |
| Users | Total No. | Ph.D./ Grad | DOE/NSF/Other US/Foreign | |
| FY2000 | 231 | 84% / 16% | 44% / 7% / 26% / 23% | |

** 88-Inch Cyclotron funding and NSD staff are also included in Division totals above.

## Overview

The Nuclear Science Division (NSD) conducts basic research in five areas:

- Low Energy Nuclear Physics at the 88-Inch Cyclotron. Research areas at this facility include nuclear structure (Gammasphere), heavy element studies (Berkeley Gas-Filled Separator/BGS) and on-line chemistry systems, weak interaction studies (radioactive ion trapping), exotic nuclei (BEARS - Berkeley Experiments with Accelerated Radioactive Species), and systematic studies of nuclear reactions (fission - fusion).
- Neutrino Astrophysics/Science. A growing program is carried out in collaboration with other institutions (worldwide) at the Sudbury Neutrino Observatory (SNO) and now at KamLAND (in Japan).
- Relativistic Nuclear Collisions (RNC). The RNC group plays a leading role in the STAR detector at RHIC. The group was responsible for the design and construction of the STAR TPC and its electronics, the tracking software, and project management. The RNC group continues to be a leader in the physics analysis.

- Nuclear Theory. A strong theory group interacts with our experimental program, conducting research activities across a broad spectrum of topics, spanning low to high energies.
- Nuclear Data. The Isotopes Project is part of the national nuclear data program, providing expertise in data evaluation and dissemination.

The Nuclear Science Division operates the 88-Inch Cyclotron as a national user facility, for both the U.S. and international low-energy communities, providing beams from protons to heavy nuclei at high intensities. Gammasphere, a national user facility, has returned to the 88-inch Cyclotron (for its 3rd campaign) to continue its forefront research program. Active R&D on ECR ion sources has provided continuing upgrading of not only the 88-Inch's capabilities for the research community, but also for many accelerators around the world.

**NSAC questions**

1. **New Research Initiatives and Facility Upgrades:** Instrumentation development utilizing the scientific, computational and technical infrastructure of Lawrence Berkeley National Laboratory (LBNL) continues to be a key to our future research directions. Many of the new activities and upgrades planned or being explored are highlighted below; they have also been included in our annual Field Work Proposals (FWPs) to DOE.

   **LOW ENERGY PROGRAM/88-INCH CYCLOTRON**
   - Upgrade the 88-Inch Cyclotron so it is able to provide forefront stable beam capabilities through the coming decade
     - Complete VENUS: 3rd generation superconducting ECR source and prototype for RIA driver ion source
     - New high voltage, high intensity injection system
   - GRETA: next generation γ-ray detector array, key part of RIA instrumentation
   - BGS upgrades: world-class heavy element program
   - Upgrade/improvement of ion trapping facility FEAT
   - BEARS: radioactive (C,N,O) beams
   - Participation in RIA science and R&D

   **NEUTRINO ASTROPHYSICS/SCIENCE**
   - KamLAND (ν-oscillations) - waveform capture electronics
   - IceCube at South Pole (ν-astronomy) - waveform capture electronics
   - Cuorcino/CUORE (ββ-decay) - neutron transmission doped thermistors

   **RELATIVISTIC NUCLEAR COLLISIONS**
   - Participation in STAR spin physics program at RHIC
   - Development of next generation high resolution vertex detector for STAR
   - PDSF computing upgrades for data analysis for the STAR collaboration

   **THEORY**
   - Strengthen program in low-energy nuclear physics

2. **FY01 Budget – its Implications:** Our DOE support has not kept up with "true" inflation over the last 5-10 years. For example, from FY98 to FY01 our budget increased only 4.5% in "real dollars" while the cost of doing business increased ~16% (or ~5% **each year)**. This has severely stressed our

ability to provide the needed level of resources to our research programs as well as operation of the 88-Inch Cyclotron. We have been operating in a lean and cost-effective manner for years, but to stay competitive we need a budget increase of about 10% for FY02.

Cooperation among DOE, NSD and LBNL management has been able to make up the short fall in the 88-Inch Cyclotron operations budget (~$300k or ~7%) for this year. Operating costs are expected to rise by 4 - 5% next year. Without at least a 10% increase in FY02 funding, running time will have to be drastically reduced and there will be cuts in the support staff. This would devastate the scientific programs dependent on the cyclotron, especially the large user community associated with Gammasphere and the heavy-element research with the BGS.

For other division programs, without an ~10% increase, we will endeavor to remain at the scientific forefront, but there will be significant staff reductions resulting in curtailment or delay of new initiatives and exciting research opportunities. It could even mean the potential closeout of one or more research programs. We note that since layoffs are based on seniority, they mainly impact the young, active scientific staff of the division.

We have recently added a divisional fellow to our nuclear theory group – to provide breadth to the program, as supported by recent DOE and LBNL director's reviews. Since the theory budget has also experienced "flat" funding for the past few years, the new hire depends crucially on increased support next year. The postdoctoral and visitor programs (e.g., foreign fellows with their own support and a modest summer visitor program) are vital not only to the local theory group but also to the division's experimental program. Without increased support we will not be able to maintain these theory programs at their minimum viable level.

As already noted, a 10% increase is needed just to maintain the current programs. Any additional increase above that would allow us to more adequately support our experimental research programs by, for example, adding new, young staff members. We are presently about 3-4 postdocs below the level needed to realize the full potential of our low-energy program, in particular, the heavy-element program and the continuing search for superheavies. The neutrino effort, particularly with the fast track associated with KamLAND, is in need of additional postdoctoral fellows as well. Two additional postdocs are vital for our commitments to this international project and for physics analysis of neutrino experiments.

In addition, increased equipment funds (on the order of $500k over the next 3 years) would allow us to provide needed experimental support (e.g., specialized detectors and electronics) for the 88-Inch Cyclotron user community.

3. **Balance of Research (Inside/Outside LBNL):** We enjoy strong programs both inside the Berkeley lab (88-Inch Cyclotron) and outside (RHIC/ SNO/KamLAND), with the split between these being approximately 50/50. This is about the same as the balance at the time of the 1996 Long Range Plan (LRP). However, the RNC group has since consolidated all its activities at STAR. With the successful completion of the SNO construction project, we continue to be active participants in its physics phase, while looking at new opportunities such as KamLAND. Our involvement in non-accelerator based neutrino studies has therefore increased since the 1996 LRP. For the future (3 - 5 years) we are looking at modest growth (partly related to RIA instrumentation and science).

4. **Attracting/Supporting Graduate Students:** The NSD and LBNL enjoy a close connection with the University of California Berkeley campus, as well as ties to UC Davis and UCLA. On the Berkeley campus, five (5) university professors share joint appointments with the NSD. In the Physics Department, Professor Stuart Freedman, and in the Chemistry Department, Professors Joe Cerny, Darleane Hoffman (retired) Luciano Moretto and Heino Nitsche. These professors provide a primary conduit of graduate students - particularly for research at the 88-Inch Cyclotron. NSD staff members may supervise graduate students from the Physics Department and the Nuclear Engineering Department and have taken advantage of this whenever the opportunity has arisen (~1 student/year). NSD staff members have also been thesis advisors for students outside the UC system (generally from a collaborating institution). On average, 5 Ph.D. theses have been completed each year for the past 10 years. There are often requests by undergraduate students to work with NSD group members on a part-time basis. This has been highly beneficial, but limited by availability of resources. We view training as an essential part of our mission and can attract more students. The principal limitation, and it is a serious one, is the resources to support these students.

5. **Other Unique Aspects of NSD and LBNL:** A hallmark of our success in conducting world-class science has been the ability to conceive and bring into operation advanced nuclear instrumentation. This has required the resources available at a national laboratory and active collaborations with other institutions. Recent examples include: 1) the EOS TPC (used at the Bevalac and AGS, and now residing at FNAL), the STAR TPC now producing its first results at RHIC, 2) Gammasphere, 3) the BGS, 4) SNO and 5) the superconducting 3$^{rd}$ generation ECR ion source (VENUS) now in the construction phase. At the present time we are actively collaborating on KamLAND. Unique in all these are the connections within the laboratory which provide extraordinary capabilities in electronics, electrical and mechanical engineering, and project management. Active collaborations among the AFRD (Accelerator and Fusion Research Division), Engineering, NSD and the Physics Division have produced forefront science and scientific instruments. Large-scale detectors such as STAR, Gammasphere, and the PMT support structure for SNO, etc., were the result of close collaboration with our Engineering Division.

   With the growing importance of data-intensive computing in nuclear physics, the computational facilities of NERSC and the PDSF at LBNL are critical resources. For example, only ~50% of the computing needs of the STAR collaboration can be provided by the RHIC computing facility (at BNL). This led NERSC, with its infrastructure and computing expertise, to establish the PDSF facility to support the additional computing needs of the entire STAR collaboration. Other major experiments, e.g., SNO and KamLAND, are also utilizing this resource. Perhaps the PDSF can serve as a prototype to satisfy other needs in both nuclear and high energy physics.

   The NSD also operates (on a recharge basis) a low-background counting facility used to characterize material samples, particularly where extremely low levels of activity are required (e.g., SNO).

   Much of the science we are engaged in today lies at the intersection of nuclear and particle physics. The INPA (Institute for Nuclear and Particle Astrophysics) is an organization sponsored jointly by the NSD and Physics Division that strengthens these connections.

   Our connections to the UCB campus integrate research and education, combining the benefits of an academic environment with the resources of a national laboratory.